

UTILITY PATENT
DOCKET # SOU-2059
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**APPARATUS AND METHOD FOR REINFORCING CONCRETE
USING INTERSECTIONAL TENDON SUPPORT STRUCTURES**

RELATED APPLICATION

[0001] This application claims priority under 356 U.S.C. §119(e) to U.S. Provisional Patent Application Serial No. 463,714, filed on 16 April, 2003, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

TECHNICAL FIELD

[0002] The present invention relates generally to reinforced concrete and more specifically to suspending and positioning multi-stranded cables (tendons) in the footings and foundations of buildings and other structures.

BACKGROUND ART

[0003] Pre-stressed concrete is a type of reinforced concrete that has been subjected to an external compressive force prior to the application of loads. Typical applications for pre-stressed concrete include slab-on-grade construction and the like. A compressive force may be provided within the concrete slab by placing steel tendons within the concrete slab. The tendons are initially tensioned with hydraulic jacks and held in tension by end anchors.

[0004] Pre-stressed concrete may be broadly categorized as either pre-tension or post-tension. Pre-tension refers to the method of first stressing tendons and then casting concrete around the pre-stressed tendons. The concrete cures before releasing the pre-stressed tendons and transferring the stress from the tendons to the concrete. Post-tension refers to the method of casting concrete around unstressed tendons and then stressing the tendons after the concrete has reached a specified strength.

[0005] Although the modern method of pre-stressing concrete may be traced to the late 1920's, its general use in the United States did not begin until the late 1940's or early 1950's. General acceptance and the primary increase in use occurred primarily between 1965 and 1975. Application of pre-stressed concrete was being made in all aspects of construction including buildings, towers, floating terminals, ocean structures and ships, storage tanks, nuclear containment vessels, bridge piers, bridge decks, foundations, soil anchors, and virtually all other types of installations where normal reinforced concrete was acceptable. Thus, pre-stressed concrete and methods for its initial installation for diverse applications is now well known.

[0006] When placing the tendons in position for a typical concrete slab-on-grade, the tendons are placed in a crossing pattern, with a first group of tendons reaching from one end of the slab to the other end of the slab, such that each of the first group of tendons are arranged so as to be evenly spaced along one edge of the slab and substantially parallel to each of the other tendons in the first group of tendons. Then, a second group of tendons are

placed and evenly spaced along another edge of the slab so as to extend from one edge of the slab to the opposite edge of the slab. Similar to the first group of tendons, each of the second group of tendons is laid so as to be substantially parallel to each of the other tendons in the second group of tendons. Additionally, each of the tendons in the second group of tendons are substantially perpendicular to each of the tendons in the first group of tendons, with the first and second group of tendons forming a lattice-work arrangement of the first and second group of tendons.

[0007] Since the tendons are typically placed to provide structural strength to the slab, it is desirable to suspend the latticework structure of tendons in the air, thereby allowing the concrete to encase the tendons within the slab when the slab is poured. Depending on the size of the slab, it is not uncommon for the weight of the tendons to cause the tendons to “sag” or “droop” in the middle as the tendons are laid from one end of the slab to the other. This is generally considered to be undesirable because if the tendons are not properly positioned in the center of the concrete slab after it is poured in place, the structural integrity of the resulting slab may be compromised.

[0008] In order to prevent the undesirable sagging of the tendons, it is now typical to employ “intersectional chairs” to support the tendons wherever a tendon from the first group of tendons crosses a tendon from the second group of tendons. At each of these intersections, a small plastic device is positioned to support the tendons at the desired height. Additionally, it is also fairly common to use “tie wire” to connect the criss-crossing tendons to each other

and to the intersectional chairs at these intersection to further secure the tendons in place.

Once the tendons have been properly positioned, the concrete is poured over the tendons and allowed to cure, embedding the suspended tendons within the concrete slab. Then, the individual tendons are tensioned, using hydraulic jacks or some other means of applying tension to cables and the like; thereby providing additional structural strength to the concrete slab after it is poured in place.

[0009] Although the above-mentioned practices are convenient and generally well accepted in the construction industry, they are not without certain limitations. One of the most significant issues is the amount of time that is required to secure the tendons in place using existing conventional intersectional supports and tie wires. Since the placement of the tendons is generally a manual process, it can be very time-consuming to place and secure each tendon to each crossing tendon. Additionally, the use of wire to tie the tendons in place can provide for less than optimal stability. In some cases, the wire is not tied securely and the weight of the concrete being poured over the tendons can cause the tendons to be dislodged and shifted out of position. Alternatively, the tendons may shift or rotate in place, further destabilizing the entire support system. If this happens, the structural integrity of the resulting concrete foundation or structure may be comprised. Any such undesirable movement of the tendons requires an even more time-consuming operation to retrieve the dislocated tendons and replace it into the proper location or locations.

[00010] Although there have been various other support devices developed which are designed to hold tendons in place, the most common practice, as explained above, involves the use of intersectional chairs and tie wires to support the tendons prior to pouring the concrete. However, as previously mentioned, the problem with this method is that the tendons are not always fixed firmly in place and may be subject to possible displacement when the concrete is poured over the tendons. Once out of position, the tendons may not adequately perform the function of reinforcing the concrete because the tendons are no longer in the position where they were intended to be. Other methods, while somewhat different, suffer from the same basic limitations.

[00011] Additionally, although the latticework of tendons may be supported by small plastic chairs that are placed at the intersections where the tendons cross, the present methods are still lacking. While somewhat effective, the present tendon support chairs merely provide a resting place for the tendons and do not securely hold the tendons in place, generally requiring the installation of tie wires. The time-consuming task of installing tie wires at the intersection of each pair of tendons is inefficient and costly.

[00012] Accordingly, without an improved tendon support apparatus that can properly support and position the tendons in the appropriate location and orientation, while simultaneously providing an inexpensive, quick and easy installation process that fixes the tendons firmly in place and maintains the requisite stability, the structural integrity and

performance effectiveness associated with the placement and support of tendons in slab-on-grade foundations will continue to be sub-optimal.

BRIEF SUMMARY OF THE INVENTION

[00013] The present invention provides an apparatus and method for positioning and supporting multi-stranded cables (tendons) within a slab-on-grade foundation or other type of concrete structure. Each tendon support structure of the present invention comprises at least one tendon support arm that, in concert with the other components of the foundation or concrete structure, supports one or more tendons in a desired orientation within a slab-on-grade construction. The most preferred embodiment of the present invention comprises a support base with a removably insertable portion for suspending support tendons in place.

BRIEF SUMMARY OF THE DRAWINGS

[00014] The preferred embodiments of the present invention will hereinafter be described in conjunction with the appended drawings, wherein like designations denote like elements, and:

[00015] FIG. 1 is a perspective view of a tendon support structure according to a preferred exemplary embodiment of the present invention;

[00016] FIG. 2 is a side view of the tendon support structure of FIG. 1, showing a cross-sectional piece of a tendon being inserted into a tendon support structure in accordance with a preferred exemplary embodiment of the present invention;

[00017] FIG. 3 is a perspective view of a tendon support structure in accordance with an alternative preferred embodiment of the present invention;

[00018] FIG. 4 is a perspective view of a plurality of tendon support structures deployed to support a plurality of tendons in accordance with a preferred exemplary embodiment of the present invention; and

[00019] FIG. 5 is a perspective view of a plurality of tendon support structures deployed to support a plurality of tendons in accordance with an alternative preferred exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[00020] Referring now to FIG. 1, a tendon support structure 100 in accordance with a preferred exemplary embodiment of the present invention is shown. Tendon support structure 100 comprises: an upper support base or ring 110; a lower support base or ring 120; a plurality of connecting legs 130; a pair of tendon-receiving portions 140 and a tendon-receiving portion 150 which are all incorporated into a support base 160. Tendon-receiving portions 140 are configured to receive a first tendon positioned horizontally in a first

horizontal plane and tendon-receiving portion 150 is configured to receive a second tendon, substantially perpendicular to the first tendon, and positioned in a second horizontal plane. Upper support ring 110 and lower support ring 120 are connected to connecting legs 130. Connecting legs 130 are each connected to support base 160 and tendon-receiving portions 140, along with tendon receiving portion 150, and are integral parts of support base 160.

[00021] Upper support ring 110 and lower support ring 120 provide lateral support for connecting legs 130 and prevent connecting legs 130 from bending too far in any given direction. While upper support base or ring 110 and lower support base or ring 120 are shown as circular in form, those skilled in the art will recognize that other geometries may be employed. For example, upper support ring 110 and lower support ring 120 may be manufactured with a substantially rectangular orientation without departing from the spirit and scope of the present invention. However, in the most preferred embodiments of the present invention, upper support ring 110 and lower support ring 120 are substantially flat and circular in shape and oriented so as to lie in substantially parallel planes.

[00022] Additionally, other preferred embodiments of the present invention may involve other configurations of tendon support structure 100. In at least one of these alternative preferred embodiments, an additional support ring may be added. In yet another alternative preferred embodiment of the present invention, upper support ring 110 may be omitted. While less stable, this embodiment would be less expensive to manufacture and may be

especially useful where the thickness of the slab-on-grade is relatively small and, correspondingly, the overall height of tendon support structure 100 is similarly small.

[00023] The overall height of tendon support structure 100 will be determined by the specific application. In general, the height will be appropriate so as to position the tendons in the appropriate horizontal plane for the interior of the proposed concrete slab-on-grade construction project.

[00024] Although described herein as a series of interconnected parts, tendon support structure 100 is most preferably manufactured in a single, unitary piece from a durable, resilient non-metallic material such as plastic. This can be accomplished by any of the techniques and practices known to those skilled in the art, including the various mold processes used to manufacture most relatively small and inexpensive plastic items.

[00025] While tendon support structure 100 is most preferably manufactured from plastic or some similar material, the most preferred embodiments of the present invention may be manufactured using any material that is not be overly hard or brittle. There should be some “give” to the material so that tendon-receiving portions 140 and tendon-receiving portion 150 can “flex” without breaking. This will allow tendon receiving portions 140 and tendon-receiving portion 150 to respectively accept sections of tendons without breaking and will allow tendon support structure 100 to withstand the various forces to which it is subjected during the concrete pouring operation without cracking or otherwise degrading.

[00026] Referring now to FIG. 2, a side view of a tendon-receiving portion 140 is shown in conjunction with a first tendon 210 and a second tendon 220. As shown in FIG. 2, points 241 and 242 define a distance "D." Distance D is somewhat smaller than the outer diameter of tendon 210. Accordingly, when tendon 210 is to be positioned in tendon-receiving portion 140, tendon 210 is urged downward against points 241 and 242, applying pressure to points 241 and 242. Due to the somewhat resilient nature of the material used to manufacture tendon support structures 100, each of points 241 and 242 are thereby forced by the downward pressure exerted by tendon 210 to move from a first point to a second point in a direction generally perpendicular to the downward force exerted by tendon 210 and slightly away from each other. This allows tendon 210 to slip into the interior portion of tendon-receiving portions 140 and 150.

[00027] Tendon-receiving portions 140 and 150 are most preferably manufactured with an inner diameter slightly larger than the outer diameter of tendon 210, thereby allowing tendon 210 to fit comfortably with the confines of tendon receiving portions 140 and 150. After tendon 210 passes points 241 and 242, points 241 and 242 are able to return to their original position, thereby securely fixing tendon 210 in place within the confines of tendon-receiving portion 140. Since the concrete will be poured over the top of tendon 210, the downward pressure of the concrete will not be likely to dislodge tendon 210 from tendon-receiving portion 140. Those skilled in the art will recognize that tendon-receiving portion 140 may be manufactured in practically any size, thereby accommodating various sizes of tendons 210.

[00028] Finally, as shown in FIG. 2, a tendon 220 is positioned substantially perpendicular to and slightly beneath tendon 210. In the most preferred embodiments of the present invention, tendon 210 and tendon 220 do not touch, but are isolated by their respective tendon-receiving portions 140. Additionally, for the most preferred embodiments of the present invention, tendon 210 is held in place by two tendon-receiving portions 140 and tendon 220 is held in place by a single tendon-receiving portion 150.

[00029] Referring now to FIG. 3, a tendon support structure 300 in accordance with an alternative preferred exemplary embodiment of the present invention is shown. Tendon support structure 300 comprises an insert portion 310 and a support base 380.

[00030] Insert portion 310 comprises tendon receiving portions 340 and a tendon receiving portion 350. Tendon-receiving portions 340 are configured to receive a first tendon positioned horizontally in a first horizontal plane and tendon-receiving portion 350 is configured to receive a second tendon, substantially perpendicular to the first tendon, and positioned in a second horizontal plane.

[00031] Support base 380 comprises a lower support ring 320; a plurality of connecting legs 330 and a support cylinder 325. Support cylinder 325 is substantially cylindrical and is connected to connecting legs 330. Connecting legs 330 are each connected to lower support ring 320. In the most preferred embodiments of the present invention, four connecting legs 330 are spaced equidistant around support base 380. Support cylinder 325 defines an aperture

support base opening 324. Support base opening 324 is sized and configured so as to receive neck 312 of insert portion 310. Accordingly, the outer diameter of neck 312 is slightly smaller than the inner diameter of support base opening 324. However, the difference in the two diameters is very small and, accordingly, once neck 312 is inserted into support base opening 324, it is held in place and they are capable of function as a unitary apparatus.

[00032] Lower support ring 320 provides lateral support for tendon support structure 300 by to connecting legs 330 and prevents connecting legs 330 from bending too far in any given direction. While lower support base or ring 320 is shown as circular in form, those skilled in the art will recognize that other geometries may be employed. For example, lower support ring 320 may be manufactured in a substantially rectangular configuration without departing from the spirit and scope of the present invention. However, in the most preferred embodiments of the present invention, lower support ring 320 is substantially flat and circular in shape and oriented so as to lie in a substantially parallel plane with any tendons.

[00033] Additionally, other preferred embodiments of the present invention may involve other configurations of tendon support structure 300. In at least one of these alternative preferred embodiments, an additional support ring may be added (as shown in FIG. 1) while retaining the two-piece construction shown in FIG. 3.

[00034] While tendon support structure 300 is most preferably manufactured from plastic or some similar material, the most preferred embodiments of the present invention may be

manufactured using any material that is not be overly hard or brittle. In the most preferred embodiments of the present invention, there should be some “give” to the material so that tendon-receiving portions 340 and tendon-receiving portion 350 can “flex” without breaking. This will allow tendon receiving portions 340 and tendon-receiving portion 350 to respectively accept sections of tendons 210 and 220 without breaking and will also allow tendon support structure 300 to withstand the various forces to which it is subjected during the concrete pouring operation without cracking or otherwise degrading. Cost may also be a factor in material selection.

[00035] As shown in FIG. 3, insert portion 310 may be removably inserted into support base 380 by inserting neck 312 into support base opening 324. Once neck 312 has been inserted into support base opening 324, insert portion 310 may be rotated in a clockwise or counterclockwise through a full 360°. Additionally, by varying how much of insert portion 310 is inserted into support base opening 324, the present inventions allows a user to accommodate various height requirements for tendon support structure 300 in the field at the point of application.

[00036] The overall height of tendon support structure 300 will be determined by the specific application. In general, the height will be appropriate so as to position the tendons in the appropriate horizontal plane for reinforcing the proposed concrete slab-on-grade construction project. Additionally, since insert portion 310 may be raised or lowered in the field during deployment in order to accommodate various height requirements for tendon

support structure 300, the height may vary from application to application. For example, if the grade slopes in one direction, the height of tendon support structure can be raised or lowered by simply adjusting the amount of neck 312 that is inserted into support body 380.

[00037] Referring now to FIG. 4, a perspective view of a plurality of tendon support structures 100 deployed to support a plurality of tendons 210 and tendons 220 in accordance with a preferred exemplary embodiment of the present invention is presented. As shown in FIG. 3, a tendon support structure 100 is positioned at each intersection of a tendon 210 and a tendon 220. This permits the tendon support structures 100 to act as stabilizers for the tendons 210 and tendons 220, fixing them in place and increasing the probability of maintaining the appropriate positioning for tendons 210 and tendons 220.

[00038] While the arrangement depicted in FIG. 4 is the most preferred embodiment of the present invention, it should be noted that other configurations are possible. For example, additional tendon support structures 100 could be placed at other locations other than the intersections of tendons 210 and tendons 220, such as at intermediate locations between neighboring tendons 210, to provide supplemental support for tendons 210 and tendons 220. Additionally, depending on the spacing between individual tendons 210 or tendons 220, it may not be necessary to provide a tendon support structure 100 at each intersection of tendons 210 and tendons 220.

[00039] Referring now to FIG. 5, a perspective view of a plurality of tendon support structures 300 deployed to support a plurality of tendons 210 and tendons 220 in accordance with a preferred exemplary embodiment of the present invention is presented. As shown in FIG. 5, a tendon support structure 300 is positioned at each intersection of a tendon 210 and a tendon 220. This permits the tendon support structures 300 to act as stabilizers for the tendons 210 and tendons 220, fixing them in place and increasing the probability of maintaining the appropriate positioning for tendons 210 and tendons 220.

[00040] While the arrangement depicted in FIG. 5 is the most preferred embodiment of the present invention, it should be noted that other configurations are possible. For example, additional tendon support structures 300 could be placed at other locations other than the intersections of tendons 210 and tendons 220, such as at intermediate locations between neighboring tendons 210, to provide supplemental support for tendons 210 and tendons 220. Additionally, depending on the spacing between individual tendons 210 or tendons 220, it may not be necessary to provide a tendon support structure 300 at each intersection of tendons 210 and tendons 220.

[00041] In summary, the most preferred embodiments of the tendon support structures of the present invention are used in concert with existing slab-on-grade foundation tendons members to firmly support and securely position tendons in place and to couple the various components together, thereby ensuring stable and secure structural reinforcement for a typical slab-on-grade concrete foundation. In addition, the use of tendon support structures to hold

tendons in place allows a worker to quickly and easily secure the tendons in the appropriate place without using the traditional use of tie wires. This is especially important in large slab-on-grade foundations because substantial times savings can be realized when the labor-intensive effort of individually tying each tendon intersection is circumvented.

[00042] From the foregoing description, it should be appreciated that apparatus and methods for supporting and fixing tendons in place is provided and presents significant benefits that would be apparent to one skilled in the art. Furthermore, while multiple embodiments have been presented in the foregoing description, it should be appreciated that a vast number of variations in the embodiments exist. Lastly, it should be appreciated that these embodiments are preferred exemplary embodiments only, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description provides those skilled in the art with a convenient road map for implementing a preferred exemplary embodiment of the invention, it being understood that various changes may be made in the function and arrangement of elements described in the exemplary preferred embodiment without departing from the spirit and scope of the invention as set forth in the appended claims.